Objectives

The objectives for this are three fold, the first is to introduce students to parallel computing, secondly to prepare students to apply this knowledge to a real world application, and lastly to generate interest in parallel computing on a high school level.

Reasoning

Parallel computing is a powerful analytical tool being used throughout the scientific community. With the advent of reliable and inexpensive networking, this technology enables networks to become a supercomputer. Many high schools have networks, teach computer programming, and have curriculum that can take advantage of this concept. The new parallel computer software enables even novice programmers to be successful. These lessons focus on introducing the fundamental concepts of parallel computing. There are several parallel computing programs out there, covering a vast array of applications. Mathematica offers parallel computing as an extension pack; this coupled with a network of computers with Mathematica can make for a very viable parallel computer. If your school has Mathematica, this would be the way to go. Mathematica contains many visualizations which can be exploited to illustrate parallel computing. These lessons have been geared to introduce the students towards a parallel virtual machine, particularly activity # 4. The rest are applicable to all parallel computing concepts. Parallel Virtual Machine comes from the software, PVM. The Oak Ridge National Laboratory and the University of Tennessee developed it. It was chosen for its support, ability to form a completely heterogeneous machine, cost, and its ease of use. There is an entire book on line, detailing the installation, theory, and applications. PVM is free, and it can be downloaded on line. It does require a compiler such as C++ or Fortran so the only hardware requirements are that the computers have to be able to run one of the above languages. The last positive feature is that PVM does not have to run on every machine on the network. Each user can specify the computers to be used.

Implementation

This series of lessons are designed to be integrated into a science, math, or computer programming classes. The target audience is high school students. They do not have to be done concurrently, except Activities 4, 5, and 6. The time requirements are 5- forty-minute periods with an additional period for review and assessment.

Topic/Unit Introduction

A great way of introducing this topic would be to ask the class if anyone has worked at McDonalds or some other fast food restaurant. When a student(s) raise their hands, ask them what jobs they did. Invariably, someone has worked on the grill, or in food preparation; ask these students how a burger was prepared. Write down the steps on the board or have the students write them down on the board. Lead the discussion so that the students realize that at no one person does all the food preparation. Ask the class, that given the same space and the same number of workers, could McDonalds serve so many people so fast. Lead the discussion to point out the answer should be no if they do not come up with it on their own. This is one of the reasons that fast food is fast. Why Henry Ford’s assembly line enabled him to dramatically reduce the price of a car, why computers are so cheap, and why custom clothes are so expensive. Use your own life experiences, to illustrate that our world relies on parallel processing. They may have not have thought about it like that.

Activities

1. **Introduction**
   This activity is designed to illustrate the differences between linear and parallel concepts.
   Introduction Activity.pdf & **Introduction Activity Solution.pdf**

2. **Algorithms**
   This is a brief lecture and a simple mathematical activity used to illustrate what an algorithm is and to differentiate between serial and parallel ones. See the hyperlink below for the activity.
   Algorithm.pdf

3. **Algorithms II**
   This is a brief lecture and sorting lists activity used to illustrate what an algorithm is and to differentiate between serial and parallel ones.[3, 4]
   Algorithm II.pdf

4. **Lecture Material**
   This is material necessary to develop the students understanding of parallel computing and is fundamental to the success of the MIMD and SIMD activities listed below. See hyperlinks below for guided notes for the presentation and the power point presentation.[1, 6]
   Guided Notes for Lecture.pdf & **Parallel Computing.pdf**

5. ***Distributed-memory** MIMD* **(multiple instruction multiple data)** vs. one processor computer.
   This activity is designed to illustrate how a MIMD computers work and their advantages over a single von Neumann computer. See hyperlink below activity. [1]
   MIMD Activity.pdf

6. ***SIMD*** **(single instruction multiple data)** vs. one processor computer.
   This activity is designed to illustrate how SIMD computers work, their advantages over a single von Neumann computer, and how SIMD computers differ from MIMD computers. See hyperlink for the activity. [1]
   SIMD Activity.pdf

7. **Unit Assessment**
   This assessment covers all of the content listed in each of the above activities. If you don't do all of the activities you will have to delete some questions.
   Parallel Assessment.pdf & **Parallel Assessment Solution.pdf**

National Science Standards Covered

1. **USE TECHNOLOGY AND MATHEMATICS TO IMPROVE INVESTIGATIONS AND COMMUNICATIONS.** A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, analysis, and display of data is also a part of this standard. Mathematics plays an essential role in all aspects of an inquiry. For example, measurement is used for posing questions,

formulas are used for developing explanations and charts and graphs are used for communicating results. [5]

2. **COMMUNICATE AND DEFEND A SCIENTIFIC ARGUMENT.** Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments. [5]

3. **PROPOSE DESIGNS AND CHOOSE BETWEEN ALTERNATIVE SOLUTIONS.** Students should demonstrate thoughtful planning for a piece of technology or technique. Students should be introduced to the roles of models and simulations in these processes. [5]

References

1. **http://www-unix.mcs.anl.gov/dbpp/text/node8.html**
2. Burch, Carl "Surveying the field of computing" 3rd edition, 1999, Carnegie Mellon University.
3. Maxim, Bachelis, James, and Stout. "Making Parallel Sorting Algorithms Come Alive." *MACUL Newsletter*, vol. 9 - #2 (Nov./Dec. 1988), 20-21.
4. **http://www.eecs.umich.edu/~qstout/teaching.html**
5. **http://books.nap.edu/html/nses/html/6e.html#csa912**
6. **http://www.curiousquotes.com/**